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UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No. RCOH-1013
Total Pages in this Submission 3

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

DIRECTION-SENSITIVE CORRECTION METHOD AND SYSTEM FOR DATA INCLUDING ABRUPT INTENSITY GRADIENTS

and invented by:

Shin Aoki

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below

2. ☒ Specification having 22 pages and including the following:

   a. ☒ Descriptive Title of the Invention
   b. ☐ Cross References to Related Applications *(if applicable)*
   c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   d. ☐ Reference to Microfiche Appendix *(if applicable)*
   e. ☒ Background of the Invention
   f. ☒ Brief Summary of the Invention
   g. ☒ Brief Description of the Drawings *(if drawings filed)*
   h. ☒ Detailed Description
   i. ☒ Claim(s) as Classified Below
   j. ☒ Abstract of the Disclosure

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   a. ☐ Formal Number of Sheets _____
   b. ☒ Informal Number of Sheets **13**

4. ☒ Oath or Declaration
   a. ☐ Newly executed *(original or copy)* ☒ Unexecuted
   b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   c. ☐ With Power of Attorney ☐ Without Power of Attorney
   d. ☐ *DELETION OF INVENTOR(S)*
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).

5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Computer Program in Microfiche *(Appendix)*

7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   a. ☐ Paper Copy
   b. ☐ Computer Readable Copy *(identical to computer copy)*
   c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☐ Assignment Papers *(cover sheet & document(s))*

9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*

10. ☐ English Translation Document *(if applicable)*

11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations

12. ☐ Preliminary Amendment

13. ☒ Acknowledgment postcard

14. ☒ Certificate of Mailing
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Accompanying Application Parts (Continued)

15. ☒ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☐ Additional Enclosures *(please identify below):*

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	20	- 20 =	0	x $22.00	$0.00
Indep. Claims	3	- 3 =	0	x $82.00	$0.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$790.00
OTHER FEE *(specify purpose)* _____					$0.00
				TOTAL FILING FEE	$790.00

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- ☐ Charge the amount of as filing fee.
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- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Signature

Dated: **July 1, 1999**

Ken I. Yoshida, Esq.
Reg. No. 37,009
KNOBLE & YOSHIDA LLC
Eight Penn Center, Suite 1350
1628 John F. Kennedy Blvd.
Philadelphia, PA 19103
(215) 599-0600

cc:

Direction-Sensitive Correction Method And System For Data Including Abrupt Intensity Gradients

Field of the Invention

The current invention is generally related to a method and a system for correcting image data, and more particularly related to a correctional method and system for correcting abrupt intensity data.

BACKGROUND OF THE INVENTION

In order to generate primary color signals for representing an image, a planar array of filtered charge-coupled devices (CCD) is placed in image-capturing devices such as a digital camera and a scanner. The planar array of CCDs also generates information related to the light intensity of an original image. For example, Japanese Patent Laid Publication Hei 2-128591discloses the use of four color filters with the CCDs for first generating a first set of color signals each representing Magenta, Cyan, Yellow and Green and then converting them to a second set of signals representing Red, Green and Blue. This type of approach, however, tend to cause moire and undesirable colors on edges due to an arrangement of the color filters and interpolation.

To illustrate the above problem, referring to FIGURE 1, an exemplary 3 X 3 color filtered CCDs are shown with solid lines. The color filter of the CCDs is indicated by R for red, G for green and B for Blue. These exemplary 3 X 3 CCDs arranged to include three rows of a top row having (G, R, G), a middle row having (B, G, B) and a bottom row having (G, R, G). The intensity signals generated by the above CCDs are interpolated by a set of interpolation filters such as shown in FIGURE 2 in order to generate a set of RGB primary color signals. For example, the R signal is generated by multiplying a coefficient ½ to the corresponding R intensity signal which is located in the middle of the top and

bottom rows and then by adding them. The G signal is generated by multiplying 1 to the corresponding G intensity signal which is located in the middle of the middle row. Lastly, the B signal is generated by multiplying a coefficient ½ to the corresponding B intensity signal which is located in the left and right of the middle row and then by adding them.

Now referring to FIGURES 3A and 3B, undesirable results in the RGB signals emerge when the same color filtered CCDs process an image containing abrupt intensity changes or abrupt gradients such as stripes. FIGURE 3A illustrates that the above color filtered CCDs process horizontal 2-pixel-cycle black-and-white stripes. The top and bottom row CCDs process white image portions while the middle row CCD processes a black image portion. Using the same interpolation filters as shown in FIGURE 2, the R signal is generated by multiplying a coefficient ½ to the corresponding R intensity signal having the value of 255 which is located in the middle of the top and bottom rows and then by adding them. The G signal is generated by multiplying 1 to the corresponding G intensity signal having the value of 0 which is located in the middle of the middle row. Lastly, the B signal is generated by multiplying a coefficient ½ to the corresponding B intensity signal having the value of 0 which is located in the left and right of the middle row and then by adding them. Thus, the RGB signals have the value of (255, 0, 0). This means that the color of the black-and-white stripes is now undesirably represented by red.

Referring to FIGURE 3B, the above color filtered CCDs process the same frequency black-and-white horizontal stripes. However, the top and bottom row CCDs now process black image portions while the middle row CCD processes a white image portion. Using the same interpolation filters as shown in FIGURE 2, the R signal is generated by multiplying a coefficient ½ to the corresponding R intensity signal having the value of 0 which is located in the middle of the top and bottom rows and then by adding them. The G signal is generated by multiplying 1 to the corresponding G intensity signal having the value of 255 which is located in the middle of the middle row. Lastly, the B signal is generated by multiplying a coefficient ½ to the corresponding B intensity signal having the value of 255 which is located in the left and right of the middle row and then by adding them. Thus, the RGB signals have the value of (0, 255, 255). This means that the color of the black-and-white stripes is now undesirably represented by cyan.

As described in the above, the image processing method and system remains to be improved for substantially reducing the undesirable effects such as colored edges on black-and-white stripes as well as moire problems associated with abrupt gradients in the color images.

SUMMARY OF THE INVENTION

In order to solve the above and other problems, according to a first aspect of the current invention, a method of correcting data representing abrupt intensity gradient within a predetermined set of sampled areas, including the acts of: determining a direction of the abrupt intensity gradient; determining a set of correction coefficients based upon the direction; and correcting the data using the coefficients.

According to a second aspect of the current invention, a system for correcting data representing abrupt intensity gradient within a predetermined set of sampled areas, including: a direction determination unit for determining a direction of the abrupt intensity gradient; a coefficient determination unit connected to the direction determination unit for determining a set of correction coefficients based upon the direction; and a data correction unit connected to the coefficient determination unit for correcting the data using the coefficients.

These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 illustrates an exemplary 3 X 3 color filtered CCDs.

FIGURE 2 illustrates an exemplary set of interpolation filters.

FIGURES 3A and 3B illustrate undesirable results in the RGB signals when the prior-art interpolation filters process an image containing abrupt intensity changes or abrupt gradients such as stripes.

FIGURE 4A illustrates one preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention.

FIGURE 4B illustrates acts involved in one preferred process of correcting image data including abrupt intensity gradient according to the current invention.

FIGURE 5 illustrates a second preferred embodiment 1 of the system for correcting image data including abrupt intensity gradient according to the current invention.

FIGURE 6 illustrates the location of a 3 x 3 color filter unit within a 4 x 4 CCD unit.

FIGURE 7 illustrates four different patterns or arrangements of the color filters depending upon the location of a 3 x 3 color filter unit within a 4 x 4 CCD unit.

FIGURE 8 illustrates one implementation of a line buffer unit.

FIGURE 9 illustrates exemplary values for the orientation-sensitive interpolation filter coefficients for a 3 x 3 color-filtered CCD.

FIGURE 10 illustrates another set of exemplary values for the orientation-sensitive interpolation filter coefficients for a 3 x 3 color-filtered CCD unit.

FIGURE 11 illustrates a degree of freedom of four.

FIGURE 12 illustrates exemplary sets of the vertical-stripe sensitive interpolation filter coefficients.

FIGURE 13 illustrates exemplary sets of the horizontal-stripe sensitive interpolation filter coefficients.

FIGURE 14 illustrates one designation for a pixel unit.

FIGURE 15 is an exemplary image data containing a certain color pattern.

FIGURE 16 illustrates a third preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention.

FIGURE 17 illustrates that interpolation filters each have a unique pattern of interpolation filter coefficients.

FIGURE 18 illustrates a fourth preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention.

FIGURE 19 illustrates exemplary matrices for vertical and horizontal orientations.

FIGURE 20 illustrates an alternative embodiment to the third and fourth preferred embodiments according to the current invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring now to the drawings, wherein like reference numerals designate corresponding structure throughout the views, and referring in particular to FIGURE 4A, one preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention includes an image-capturing device such as a digital camera 28 for capturing an image and a communication unit 27 for transmitting the digital image data to processing units. The processing units include storage devices such as a hard disk device 23 and a floppy disk device 26 for storing the digital image data and application programs, a main memory unit 22 and a central processing unit (CPU) for running an application program for correcting the image data based upon the orientation of abrupt intensity gradients, as well as output devices such as a printer 25 and a display monitor 24 for outputting the corrected image data. The corrected image data can be also stored in the storage devices.

Referring to FIGURE 4B, one preferred according to the current invention includes acts of correcting data representing abrupt intensity gradient within a predetermined set of sampled areas. The preferred process starts by inputting CCD data in act A100 and determines intensity gradient of the input data in act A110. After a row/column counter is initialized in act A120, a desired interpolation filter is selected based upon the intensity gradient which was determined in the act A110. Using the selected interpolation filter, the input CCD data is corrected one unit area at a time in act A140. If a row is not yet finished as found in act A155, the column counter is incremented and the process returns to the act A130. After each row is finished, the process now checks

whether or not an entire image is completed in act A165. If it is not completely done, the row counter is incremented in act A160 and the process returns to the act A130. When the entire image is done, the process ends.

Now referring to FIGURE 5, a second preferred embodiment 1 of the system for correcting image data including abrupt intensity gradient according to the current invention generally includes an image-capturing device 2 for capturing an image and an image data correction unit 3 for correcting the image data representing the captured image. The image-capturing device 2 has a planar array of 2 x 2 CCD pixel units as indicated by brackets in FIGURE 1. In this example, four 2 x 2 CCD units are repeatedly arranged so as to form a 4 x 4 CCD unit. Within the 4 x 4 CCD unit, one 3 x 3 color-filtered CCD unit is used to generate RGB signals as shown in solid lines in FIGURE 1. The 3 x 3 color-filtered CCD unit includes a top row of (G, R, G), a middle row of (B, G, B) and a bottom row of (G, R, G). However, the 3 x 3 color-filtered CCD unit has four different patterns or arrangements of the color filters depending upon the location of a 3 x 3 unit within the 4 x 4 CCD unit as indicated by two pairs of brackets in FIGURE 6. Both X (column) and Y (row) axes are each indicated by 0 and 1. FIGURE 7 shows the four patterns of the 3 x 3 color-filtered CCD units based upon the combinations of the above rows and columns of color filters. The two-digit combination below each 3 x 3 color-filtered CCD unit in FIGURE 7 indicates a row/column signal as shown in FIGURE 6. For example, a 3 x 3 color-filtered unit 1/0 as shown in FIGURE 7 has a top row of (G, R, G), a middle row of (B, G, B) and a bottom row of (G, R, G) and is located at row = 1, column = 0 in FIGURE 6.

Still referring to FIGURE 5, a second preferred embodiment of the image data correcting unit 3 further includes an analog-to-digital (A/D) conversion unit 4, a line buffer unit 5, a row/column counter 6, a filter coefficient selection unit 7, a set of coefficient memory units 8a-8c and a corresponding set of interpolation filters 9a-9c. The A/D conversion unit 4 converts an analog image signal from the image-capturing device 2 to a digital image signal in synchronous with a read clock signal. As shown in FIGURE 8, the line buffer unit 5 can be implemented as first-in-first-out (FIFO) delayed line memory 51a and 51b as well as three sets of three latches 52a-52c, 53a-53c and 54a-54c which correspond to the 3 x 3 CCD unit and each set is serially connected to the line memory.

The set of latches thus holds the serially transmitted image data representing the 3 x 3 pixel unit. The row/column counter 6 determines the pattern of the 3 x 3 color-filtered CCD units and generates the row/column signal which includes 0/0, 0/1, 1/0 or 1/1.

The filter coefficient selection unit 7 processes the 3 x 3 image data in a predetermined manner and compares it with a predetermined threshold. Based upon the comparison, the filter coefficient selection unit 7 generates a selection signal which is indicative of the orientation of stripes or abrupt intensity gradients in the image data. The selection signal values include 0, 1 and 2 which respectively indicate that the orientation of the abrupt intensity gradients is substantially vertical, horizontal and neither. The coefficient memory units 8a-8c each store predetermined sets of linear interpolation filter coefficients as shown in FIGURE 2 as well as predetermined sets of orientation-sensitive interpolation filter coefficients for correcting the image data. Based upon the selection signal and the row/column signal, the filter coefficient selection unit 7 further selects a set of the orientation-sensitive interpolation filter coefficients or a set of linear interpolation filter coefficients. In other words, if the selection signal is either vertical or horizontal, the filter coefficient selection unit 7 selects a set of the orientation-sensitive interpolation filter coefficients based upon the selection signal and the row/column signal. On the other hand, if the selection signal is neither vertical nor horizontal, the filter coefficient selection unit 7 selects a set of the linear interpolation filter coefficients. The interpolation filters 9a-9c generate RGB signals by multiplying the image data from the line buffer unit 5 by the selected interpolation filter coefficients and adding them for each primary color.

FIGURE 9 illustrates exemplary values for the orientation-sensitive interpolation filter coefficients for a 3 x 3 color-filtered CCD unit as shown in FIGURE 1. Given abrupt intensity gradients, the idea is to generate at least the same G interpolated value using the orientation-sensitive interpolation filter coefficients while the colored edges or stripes are substantially reduced. In this regard, the orientation-sensitive liner interpolation coefficients for the R signal and the B signal are both 1/2 and are the same as the prior art coefficients as shown in FIGURE 2. On the other hand, the orientation-sensitive interpolation coefficients for the G signal are -1/2 and 1/8 and are different from the prior art coefficients as shown in FIGURE 2. However, the total of the orientation-sensitive

interpolation coefficients for the G signal is also one. Thus, if five intensity values for the CCDs corresponding to the G signal were the same, the result of the filter interpolation would be the same as that based upon the prior art coefficients. In addition, the sum of the coefficients in the top row, the middle row and the bottom row is respectively 1/4, 1/2 and 1/4 for each of the primary RGB colors. The sum of the coefficients in the top and bottom rows equals that in the middle row. This feature substantially reduces the undesirable coloring effect of the horizontal stripes or the horizontally abrupt intensity gradients. Using the above-described horizontal-stripe sensitive interpolation filter coefficients, the RGB signals would be (128, 128, 128) for the image data as shown in FIGURES 3A and 3B. In other words, the use of the horizontal-stripe sensitive interpolation filter coefficients as shown in FIGURE 9 helps generate the RGB signal values that are substantially same as those with the prior art filter coefficients for image data without abrupt intensity gradients. At the same time, the use of the horizontal-stripe sensitive interpolation filter coefficients as shown in FIGURE 9 also helps generate the RGB signal values that represent the substantially reduced colors on the black-and-white horizontal stripes.

FIGURE 10 illustrates another set of exemplary values for the orientation-sensitive interpolation filter coefficients for a 3 x 3 color-filtered CCD unit as shown in FIGURE 1. Given abrupt intensity gradients, the idea is to generate at least the same G interpolated value using the orientation-sensitive interpolation filter coefficients while the colored edges or stripes are substantially reduced. In this regard, the orientation-sensitive liner interpolation coefficients for the R signal and the B signal are both 1/2 and are the same as the prior art coefficients as shown in FIGURE 2. On the other hand, the orientation-sensitive interpolation coefficients for the G signal are 1/2 and 1/8 and are different from the prior art coefficients as shown in FIGURE 2. However, the total of the orientation-sensitive interpolation coefficients for the G signal is also one. Thus, if five intensity values for the CCDs corresponding to the G signal were the same, the result of the filter interpolation would be the same as that based upon the prior art coefficients. In addition, the sum of the coefficients in the left column, the middle column and the right column is respectively 1/4, 1/2 and 1/4 for each of the primary RGB colors. The sum of

the coefficients in the right and left columns equals that in the middle column. This feature substantially reduces the undesirable coloring effect of the vertical stripes or the vertically abrupt intensity gradients. In other words, the use of the vertical-stripe sensitive interpolation filter coefficients as shown in FIGURE 10 helps generate the RGB signal values that are substantially same as those with the prior art filter coefficients for image data without abrupt intensity gradients. At the same time, the use of the vertical-stripe sensitive interpolation filter coefficients as shown in FIGURE 10 also helps generate the RGB signal values that represent the substantially reduced colors on the black-and-white verticals stripes.

In order to illustrate how orientation-sensitive interpolation filter coefficients are determined, given a 3 x 3 pixel unit, interpolation filter coefficients have a degree of freedom of four in order to comply with right-left and top-bottom symmetries as shown as a, b, c and d in FIGURE 11. Each of these letters represents an interpolation filter coefficient. Furthermore, these coefficients have to meet certain requirements. The requirements include that the sum of the coefficients corresponding to the R filters must be one while the sum of the coefficients corresponding to the G and B filters each has to be zero. In other words, the relationships among the coefficients as represented by the above letters in FIGURE 11 have to satisfy the following equations: $2c = 1$, $(a + 4d) = 0$, and $2b = 0$ Additionally, in order to substantially reduce the undesirable effects of the horizontal 2-pixel-cycle black-and-white stripes, the sum of the coefficients in the top and bottom rows equals that in the middle row. That is, $(2c + 4d) = (2b + a)$. From this relationship, the interpolation filter coefficients for generating the R signal thus becomes $a = 1/2$, $b = 0$, $c = 1/2$, and $d = -1/8$. By the same token, the interpolation filter coefficients for generating the G and B signals are also determined from the above relationships.

Now referring to FIGURE 12, exemplary sets of the vertical-stripe sensitive interpolation filter coefficients are illustrated in a table for the use in one preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention. Each row specifies one of the four patterns or arrangements of the color filters depending upon the location of a 3 x 3 unit within the 4 x 4 CCD unit. Each column specifies one of the primary colors RGB. Thus, a combination

of the filter pattern and the primary color specifies one of the twelve sets of the vertical-stripe sensitive interpolation filter coefficients. In each set of vertical-stripe sensitive interpolation filter coefficients, the sum of the coefficients in the right and left columns equals that in the middle column. The above

Referring to FIGURE 13, exemplary sets of the horizontal-stripe sensitive interpolation filter coefficients are illustrated in a table for the use in one preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention. Each row specifies one of the four patterns or arrangements of the color filters depending upon the location of a 3 x 3 unit within the 4 x 4 CCD unit. Each column specifies one of the primary colors RGB. Thus, a combination of the filter pattern and the primary color specifies one of the twelve sets of the horizontal-stripe sensitive interpolation filter coefficients. In each set of horizontal-stripe sensitive interpolation filter coefficients, the sum of the coefficients in the top and bottom rows equals that in the middle row.

In the above described exemplary tables for the use with the preferred embodiment, since an interpolation filter for the 3 x 3 pixel unit has a degree of four and three are used for the primary colors RGB, only one remains for orientation. Thus, only horizontal and vertical choices are used for the orientation sensitivity. Although a interpolation filter larger than the 3 x 3 pixel unit may be used to increase the degree of freedom, because of the restrictions related to the RGB primary colors, the larger interpolation filter cannot match the frequency characteristics. As a result, such a large interpolation filter is affected by a peripheral input in the filter. That is, the larger the input intensity near the edge of the interpolation filter, the less accurate the interpolation becomes. Another effect of the larger interpolation filter size is that the associated hardware such as a buffer memory and an adder requires additional capacity.

Referring to FIGURE 14, in order to determine the orientation of the intensity gradient, each filter element in a 3 x 3pixel unit is designated by V (x, y) where x is (i -1) , (i) or (i + 1) while y is (j - 1), (j) or (j + 1). Element V(i, j) is defined to be a center element and is located in the middle row and the middle column. dl is an amount of intensity change in the left direction with respect to the central V (i, j) element. Similarly,

dr is an amount of intensity change in the right direction with respect to the central V (i, j) element. dr and dd are each an amount of intensity change respectively in the up and down directions with respect to the central V (i, j) element. In summary, the following are defined:

$$\begin{aligned} dl &= |V(i-1, j) - V(i, j)| \\ dr &= |V(i+1, j) - V(i, j)| \\ du &= |V(i, j-1) - V(i, j)| \\ dd &= |V(i, j+1) - V(i, j)| \end{aligned} \qquad (1)$$

Then, a maximum of the above four values is determined. If the maximum is either dl or dr, it is determined that the intensity gradient is in a horizontal direction near the central V (i, j) element and the vertical-stripe sensitive interpolation filter coefficients are used to substantially reduce the undesirable effects of abrupt intensity gradients. On the other hand, if the maximum is either du or dd, it is determined that the intensity gradient is in a vertical direction near the central V (i, j) element and the horizontal-stripe sensitive interpolation filter coefficients are used to substantially reduce the undesirable effects of abrupt intensity gradients. In case the abrupt intensity gradient or stripes has slanted orientation in an image, the use of either the horizontal-stripe sensitive or vertical-stripe sensitive interpolation filter coefficients still results in some undesirable effects such as some moire.

In order to avoid the undesirable effects by the slanted stripes, the following equation is used:

$$dir = \max(dl, dr) - \max(du, dd) \qquad (2)$$

where dl, dr, du and dd are determined in the above equation (1) and max (dl, dr) selects the larger of the two while max (du, dd) selects the larger of the two. Furthermore, the dir value of the equation (2) is compared to a predetermined threshold value tr. If dir > tr, vertical-stripe sensitive interpolation filter coefficients are used. On the other hand, if dir

< -tr, horizontal-stripe sensitive interpolation filter coefficients are used. Finally, if dir is in neither situations, the prior-art interpolation filter coefficients as shown in FIGURE 2 are used. In order to specify one of the above three selections, for example, a coefficient selection signal having a value of 0, 1 or 2 is generated.

In summary, one preferred embodiment of the system for correcting image data including abrupt intensity gradient according to the current invention first converts an image signal from an analog image-capturing device 2 for each pixel into a digital signal via an A/D converter 4 and sends the digital signal to a line buffer 5. The line buffer 5 in turn takes out the digital data corresponding to a 3 x 3 pixel unit and sends it to a filter coefficient selection unit 7 and interpolation filters 9a-9c. A row/column counter 6 keeps track of the row and column numbers of a CCD unit in the image-capturing device 2 and generates a corresponding row/column signal indicative of a filter pattern. The row/column signal includes values 0/0, 0/1, 1/0 and 1/1, and the row/column counter 6 sends the row/column signal to coefficient memory units 8a-8c. The filter coefficient selection unit 7 performs tasks as expressed in the above equations (1) and (2) on the digital image data from the line buffer 5 to generate a result dir. The filter coefficient selection unit 7 then compares the result dir to a predetermined threshold tr so as to output a selection signal (0, 1 or 2) to the coefficient memory units 8a-8c. The selection signal is indicative of a selected set of interpolation filter coefficients from a vertical-stripe sensitive group, a horizontal-stripe sensitive group and a prior-art group. Based upon the selection signal and the row/column signal, the coefficient memory units 8a-8c select a particular set of the interpolation filter coefficients from the stored groups of interpolation filter coefficients and outputs the selected interpolation filter coefficients to interpolation filters 9a-9c. Lastly, the interpolation filters 9a-9c generate RGB signals based upon the multiplication of the image data by the selected interpolation filter coefficients and the addition of the products. Accordingly, the undesirable effects such as coloration and moire are substantially reduced by the above described interpolation method based upon the orientation of the abrupt intensity gradients.

Referring to FIGURE 15, an image containing a certain color pattern is considered. The image data contains a cyan color pattern, and the cyan color has RGB

values of R = G = 255 and B = 0. As shown, the four corners pixels, the center pixel and the two middle column pixels in the up and bottom rows have a value of 255 while the two right and left column pixels in the middle row have a value of 0. Since there is no particular or single orientation in intensity gradient in the above described image data, the image data is determined to have neither orientation, and the interpolation filters 9a-9c outputs orientation-neutral RGB signals.

Referring to FIGURE 16, a third preferred embodiment 100 of the system for correcting image data including abrupt intensity gradient according to the current invention generally includes an image-capturing device 2 for capturing an image and an image data correction unit 300 for correcting the image data representing the captured image. The image-capturing device 2 has a planar array of 2 x 2 CCD pixel units as indicated by brackets in FIGURE 1. In this example, four 2 x 2 CCD units are repeatedly arranged so as to form a 4 x 4 CCD unit. As shown in FIGURE 7, the four patterns of the 3 x 3 color-filtered CCD units based upon the combinations of the above rows and columns of color filters within the 4 x 4 CCD unit. The third preferred embodiment of the image data correcting unit 3 further includes an analog-to-digital (A/D) conversion unit 4, a line buffer unit 5, a row/column counter 6, a conversion coefficient selection unit 11, a conversion coefficient memory unit 12, a set of interpolation filters 13a-13d and a RGB conversion unit 14. The A/D conversion unit 4 converts an analog image signal from the image-capturing device 2 to a digital image signal in synchronous with a read clock signal. The line buffer unit 5 holds the serially transmitted image data representing the 3 x 3 pixel unit. The row/column counter 6 determines the pattern of the 3 x 3 color-filtered CCD units and generates the row/column signal which includes 0/0, 0/1, 1/0 or 1/1.

Still referring to FIGURE 16, the conversion coefficient selection unit 11 processes the 3 x 3 image data in a predetermined manner as described above for the filter coefficient selection unit 7 in the second preferred embodiment and compares the with a predetermined threshold. Based upon the comparison, the conversion coefficient selection unit 11 generates a selection signal which is indicative of the orientation of stripes or abrupt intensity gradients in the image data. The selection signal values include 0, 1 and 2 which respectively indicate that the orientation of the abrupt intensity gradients is

substantially vertical, horizontal and neither. The conversion coefficient memory unit 12 stores predetermined sets of linear interpolation filter coefficients as shown in FIGURE 2 as well as predetermined sets of orientation-sensitive interpolation filter coefficients for correcting the image data. Based upon the selection signal and the row/column signal, the conversion coefficient selection unit 11 further selects a set of the orientation-sensitive interpolation filter coefficients or a set of linear interpolation filter coefficients. In other words, if the selection signal is either vertical or horizontal, the conversion coefficient selection unit 11 selects a set of the orientation-sensitive interpolation filter coefficients based upon the selection signal and the row/column signal. On the other hand, if the selection signal is neither vertical nor horizontal, the conversion coefficient selection unit 11 selects a set of the linear interpolation filter coefficients. The interpolation filters 13a-13d respectively represent channels Ch0, Ch1, Ch2 and Ch3 and respectively has a unique pattern of interpolation filter coefficients as shown in FIGURE 17. Since the filter coefficients in Ch0-Ch3 are either 0 or 1, as shown below in equation (3), the task is simplified by selection and addition. Accordingly, a corresponding circuit is also simplified.

$$\begin{aligned} Ch0 &= V_{i-1,j-1} + V_{i+1,j-1} + V_{i-1,j+1} + V_{i+1,j+1} \\ Ch1 &= V_{i,j-1} + V_{i,j+1} \\ Ch2 &= V_{i-1,j} + V_{i+1,j} \\ Ch3 &= V_{i,j} \end{aligned} \tag{3}$$

A RGB converter unit 14 generates RGB signals by matrix operation between the results of the above channels Ch0-Ch3 and the selected filter coefficients from the conversion coefficient memory 12 as shown in the following equation (4):

$$\begin{aligned} r &= r0Ch0 + r1Ch1 + r2Ch2 + r3Ch3 \\ g &= g0Ch0 + g1Ch1 + g2Ch2 + g3Ch3 \\ b &= b0Ch0 + b1Ch1 + b2Ch2 + b3Ch3 \end{aligned} \tag{4}$$

By substituting the above rgb matrix with the horizontally sensitive interpolation filter coefficient matrix as shown in equation (5), the RGB signals are generated by the following equation (7):

$$\begin{bmatrix} r0 & r1 & r2 & r3 \\ g0 & g1 & g2 & g3 \\ b0 & b1 & b2 & b3 \end{bmatrix} = \begin{bmatrix} -1/8 & 1/2 & 0 & 1/2 \\ 1/8 & 0 & 0 & 1/2 \\ 1/8 & 0 & 1/2 & -1/2 \end{bmatrix} \quad (5)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} -1/8(v(i-1,j-1)+v(i+1,j-1)+v(i-1,j+1)+v(i+1,j+1)) \\ +1/2(v(i,j-1)+v(i,j+1))+1/2v(i,j) \\ 1/8(v(i-1,j-1)+v(i+1,j-1)+v(i-1,j+1)+v(i+1,j+1)) \\ +1/2v(i,j) \\ 1/8(v(i-1,j-1)+v(i+1,j-1)+v(i-1,j+1)+v(i+1,j+1)) \\ +1/2(v(i-1,j)+v(i+1,j))-1/2v(i,j) \end{bmatrix} \quad (7)$$

By substituting the above rgb matrix with the vertically sensitive interpolation filter coefficient matrix as shown in equation (6), the RGB signals are generated by the following equation (8):

$$\begin{bmatrix} r0 & r1 & r2 & r3 \\ g0 & g1 & g2 & g3 \\ b0 & b1 & b2 & b3 \end{bmatrix} = \begin{bmatrix} 1/8 & 1/2 & 0 & -1/2 \\ 1/8 & 0 & 0 & 1/2 \\ -1/8 & 0 & 1/2 & 1/2 \end{bmatrix} \quad (6)$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1/8(v(i-1,j-1)+v(i+1,j-1)+v(i-1,j+1)+v(i+1,j+1)) \\ +1/2(v(i,j-1)+v(i,j+1))-1/2v(i,j) \\ 1/8(v(i-1,j-1)+v(i+1,j-1)+v(i-1,j+1)+v(i+1,j+1)) \\ +1/2v(i,j) \\ -1/8(v(i-1,j-1)+v(i+1,j-1)+v(i-1,j+1)+v(i+1,j+1)) \\ +1/2(v(i-1,j)+v(i+1,j))+1/2v(i,j) \end{bmatrix} \quad (8)$$

Thus, the above results are substantially the same as those obtained by using the interpolation filter coefficients as shown in FIGURES 9 and 10. The above matrices can be used for correcting colors in addition to the RGB conversion. Although multiplication processes are necessary, matrix operations are generally performed by relatively simple circuits.

Referring to FIGURE 18, a fourth preferred embodiment 110 of the system for correcting image data including abrupt intensity gradient according to the current invention generally includes an image-capturing device 2 for capturing an image and an image data correction unit 310 for correcting the image data representing the captured image. The image-capturing device 2 has a planar array of 2 x 2 CCD pixel units as indicated by brackets in FIGURE 1. In this example, four 2 x 2 CCD units are repeatedly arranged so as to form a 4 x 4 CCD unit. As shown in FIGURE 7, the four patterns of the 3 x 3 color-filtered CCD units based upon the combinations of the above rows and columns of color filters within the 4 x 4 CCD unit. The fourth preferred embodiment of the image data correcting unit 3 further includes an analog-to-digital (A/D) conversion unit 4, a line buffer unit 5, a row/column counter 6, an orientation coefficient filter 15, a conversion coefficient determination unit 16, a set of interpolation filters 13a-13d and a RGB conversion unit 14. The A/D conversion unit 4 converts an analog image signal from the image-capturing device 2 to a digital image signal in synchronous with a read clock signal. The line buffer unit 5 holds the serially transmitted image data representing the 3 x 3 pixel unit. The row/column counter 6 determines the pattern of the 3 x 3 color-filtered CCD units and generates the row/column signal which includes 0/0, 0/1, 1/0 or 1/1.

Still referring to FIGURE 18, the orientation coefficient filter unit 15 processes the 3 x 3 image data in a predetermined manner as described above for the filter coefficient

selection unit 7 in the second preferred embodiment and compares the result with a predetermined threshold tr. Based upon the comparison, the orientation coefficient filter unit 15 generates a direction signal D as shown below based upon the result dir after processing the image data as described in equations (1) and (2):

$$D=\begin{cases} 1 & (if \quad dir > tr) \\ -1 & (else \quad if \quad dir < -tr) \\ dir / tr & (otherwise) \end{cases} \qquad (9)$$

The direction signal D is a normalized result. The conversion coefficient determination unit 16 stores matrices of incline orientation coefficients for each row/column signal as well as for the three directions (-1, 1 or dir/tr). FIGURE 19 illustrates exemplary matrices for vertical and horizontal orientations. Based upon the row/column signal, the conversion coefficient determination unit 16 selects a matrix of the orientation-sensitive interpolation filter coefficients or a set of linear interpolation filter coefficients and multiplies the selected matrix by the directional signal D. The conversion coefficient determination unit 16 outputs the above product to the RGB conversion unit 14. The RGB conversion unit 14 performs a matrix operation on the outputs Ch0-Ch3 of the interpolation filters 13a-13d and the above product from the conversion coefficient determination unit 16. Since the directional signal D ranges between 1 and -1 and the RGB conversion matrix is continuously modified by the directional signal D, the orientation sensitivity is continuous between the horizontal and vertical stripes. In other words, two pairs of interpolation coefficients r0, r3 and b0, b3 in the equations (5) and (6) have opposite signs, and these interpolation coefficients are multiplied by the directional signal D which ranges from 1 to -1. Thus, the correction substantially reduces the undesirable effects of the abrupt intensity gradients at any orientation in a continuous manner.

Referring to FIGURE 20, in stead of modifying the interpolation coefficients in the RGB conversion matrix as in the above described third and fourth preferred embodiments, an alternative embodiment corrects the data Ch0-Ch3 from the interpolation filters 13a-13d using the directional signal D. In other words, the orientation coefficient

filter unit 15 outputs the directional signal D directly to the RGB conversion unit 14. A modified conversion coefficient determination unit 16a stores matrices of incline orientation coefficients for each row/column signal as well as for the three directions (-1, 1 or dir/tr). FIGURE 19 illustrates exemplary matrices for vertical and horizontal orientations. Based upon the row/column signal, the modified conversion coefficient determination unit 16a selects a matrix of the orientation-sensitive interpolation filter coefficients or a set of linear interpolation filter coefficients and outputs the selected matrix to the RGB conversion unit 14. The RGB conversion unit 14 generates the RGB signals based upon the outputs Ch0-Ch3 of the interpolation filters 13a-13d and the directional signal D from the orientation coefficient filter unit 15 using the following equation (10).

$$\begin{aligned} R &= r0DCh0 + r1Ch1 + r2Ch2 + r3DCh3 \\ G &= g0DCh0 + g1Ch1 + g2Ch2 + g3DCh3 \\ B &= b0DCh0 + b1Ch1 + b2Ch2 + b3DCh3 \end{aligned} \qquad (10)$$

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and that although changes may be made in detail, especially in matters of shape, size and arrangement of parts, as well as implementation in software, hardware, or a combination of both, the changes are within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

WHAT IS CLAIMED IS:

1. A method of correcting data representing abrupt intensity gradient within a predetermined set of sampled areas, comprising the acts of:

a) determining a direction of the abrupt intensity gradient;

b) determining a set of correction coefficients based upon the direction; and

c) correcting the data using the coefficients.

2. The method of correcting data according to claim 1 wherein the abrupt intensity gradient is stripes.

3. The method of correcting data according to claim 2 wherein the direction of the stripes is horizontal.

4. The method of correcting data according to claim 2 wherein the direction of the stripes is vertical.

5. The method of correcting data according to claim 1 wherein the sampled areas are covered by a planar array of color area image sensors.

6. The method of correcting data according to claim 1 wherein the color area image sensors generate primary colors.

7. The method of correcting data according to claim 6 wherein for each of the primary colors, the set of correction coefficients is selected based upon the direction of the abrupt intensity gradient.

8. The method of correcting data according to claim 7 wherein the direction includes a vertical type and a horizontal type.

9. The method of correcting data according to claim 8 wherein the set of correction coefficients is selected additionally based upon ~~a pattern~~ of the planar array of the color area image sensors.

10. The method of correcting data according to claim 7 wherein the direction includes a vertical type, a horizontal type and an all-other type.

11. The method of correcting data according to claim 9 wherein the direction is continuous.

12. A system for correcting data representing abrupt intensity gradient within a predetermined set of sampled areas, comprising:

a direction determination unit for determining a direction of the abrupt intensity gradient;

a coefficient determination unit connected to the direction determination unit for determining a set of correction coefficients based upon the direction; and

a data correction unit connected to the coefficient determination unit for correcting the data using the coefficients.

13. The system for correcting data according to claim 12 wherein the direction determination unit detects the direction of the abrupt intensity gradient including vertical stripes and horizontal stripes.

14. The system for correcting data according to claim 12 further includes a planar array of color area image sensors for generating signals representing primary colors in the sampled areas.

15. The system for correcting data according to claim 14 wherein the coefficient determination unit selects the set of correction coefficients based upon the direction of the abrupt intensity gradient for each of the primary colors.

16. The system for correcting data according to claim 15 wherein the direction determination unit determines a vertical type and a horizontal type.

17. The system for correcting data according to claim 16 wherein the coefficient determination unit selects the set of correction coefficients additionally based upon a pattern of the planar array of the color area image sensors.

18. The system for correcting data according to claim 16 wherein the direction determination unit determines a vertical type, a horizontal type and an all-other type.

19. The system for correcting data according to claim 15 wherein the direction determination unit determines the direction in a continuous angle.

20. A medium containing computer instructions performing a task of correcting data representing abrupt intensity gradient within a predetermined set of sampled areas, comprising the acts of:

determining a direction of the abrupt intensity gradient including stripes, the sampled areas being covered by a planar array of color area image sensors, the color area image sensors generating primary colors;

determining a set of correction coefficients based upon the direction; and

correcting the data using the coefficients.

ABSTRACT OF THE DISCLOSURE

The use of the orientation-sensitive interpolation filter coefficients generates the RGB signal values that are substantially same as those with the prior art filter coefficients for image data without abrupt intensity gradients. At the same time, the use of the same orientation-sensitive interpolation filter coefficients also helps generate the RGB signal values that represent the substantially reduced colors on the black-and-white horizontal stripes.

FIG. 1
(PRIOR ART)

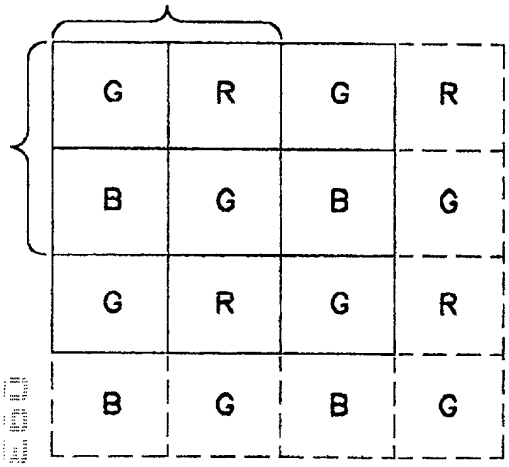


FIG. 6
(PRIOR ART)

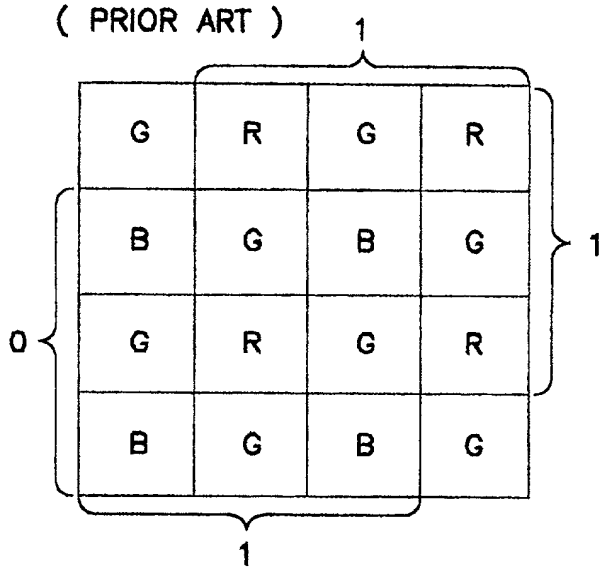
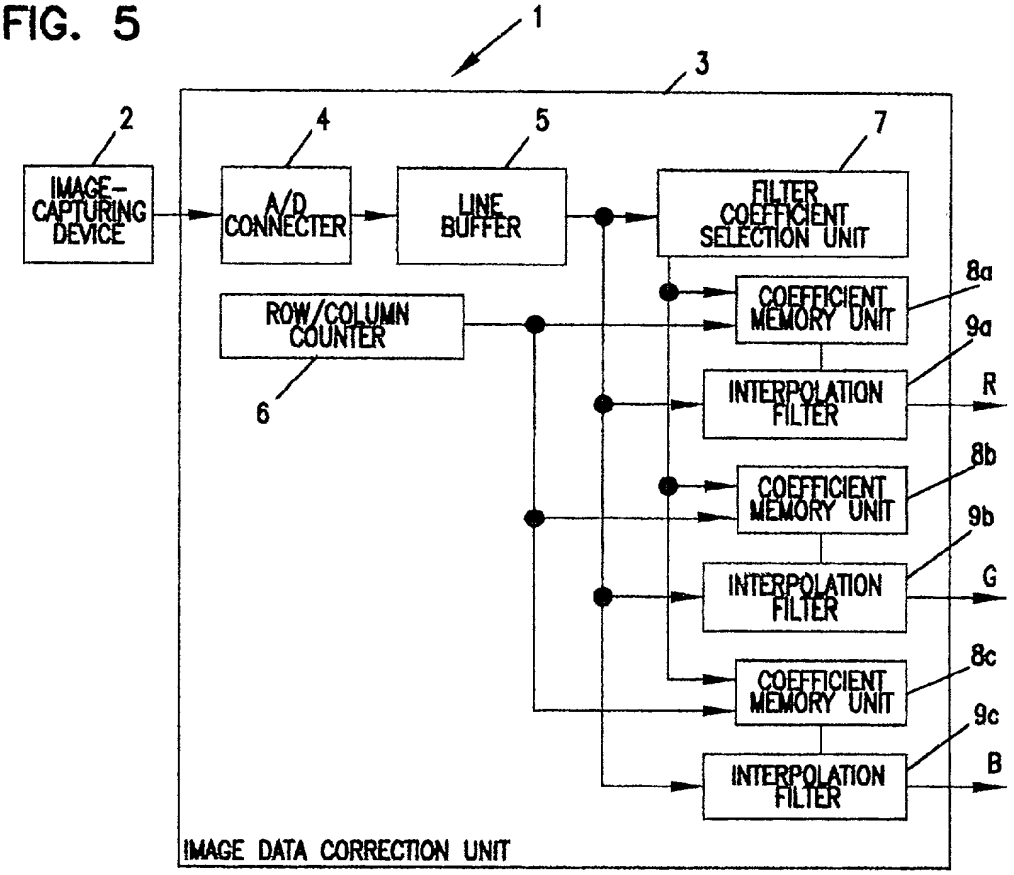


FIG. 5



FROM :

FIG. 3A
(PRIOR ART)

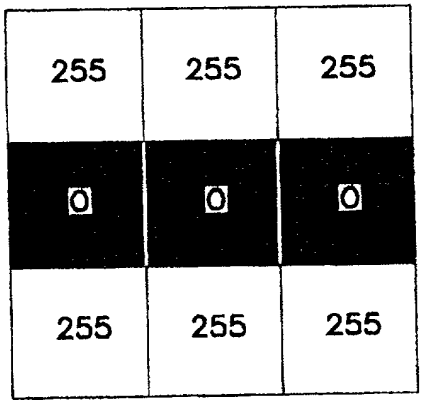


FIG. 3B
(PRIOR ART)

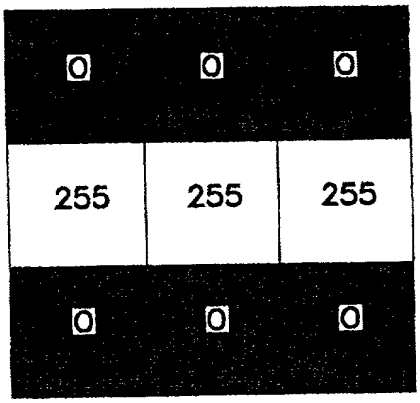


FIG. 9

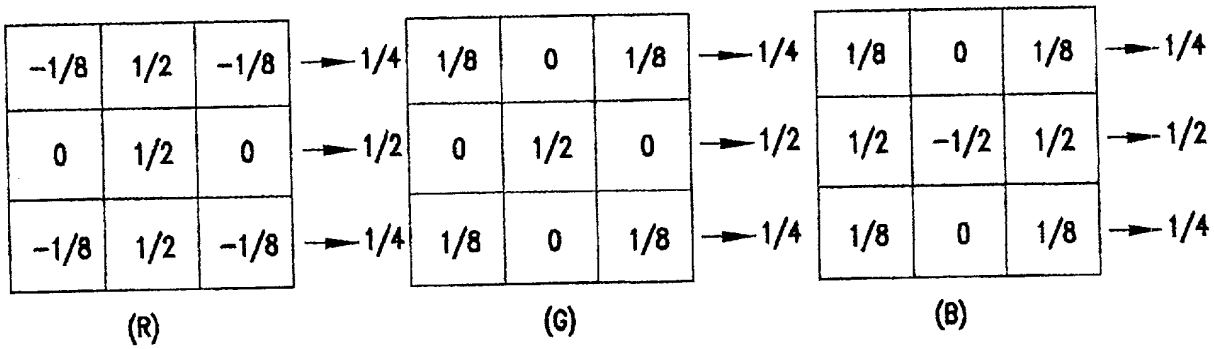


FIG. 10

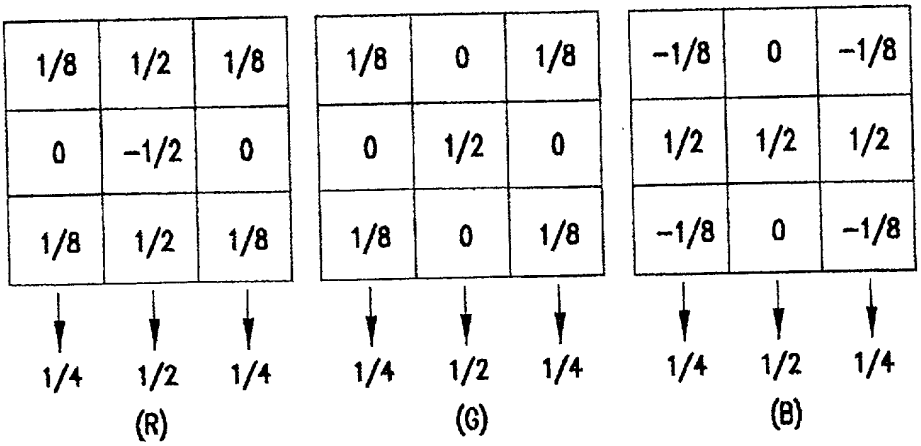


FIG. 4A

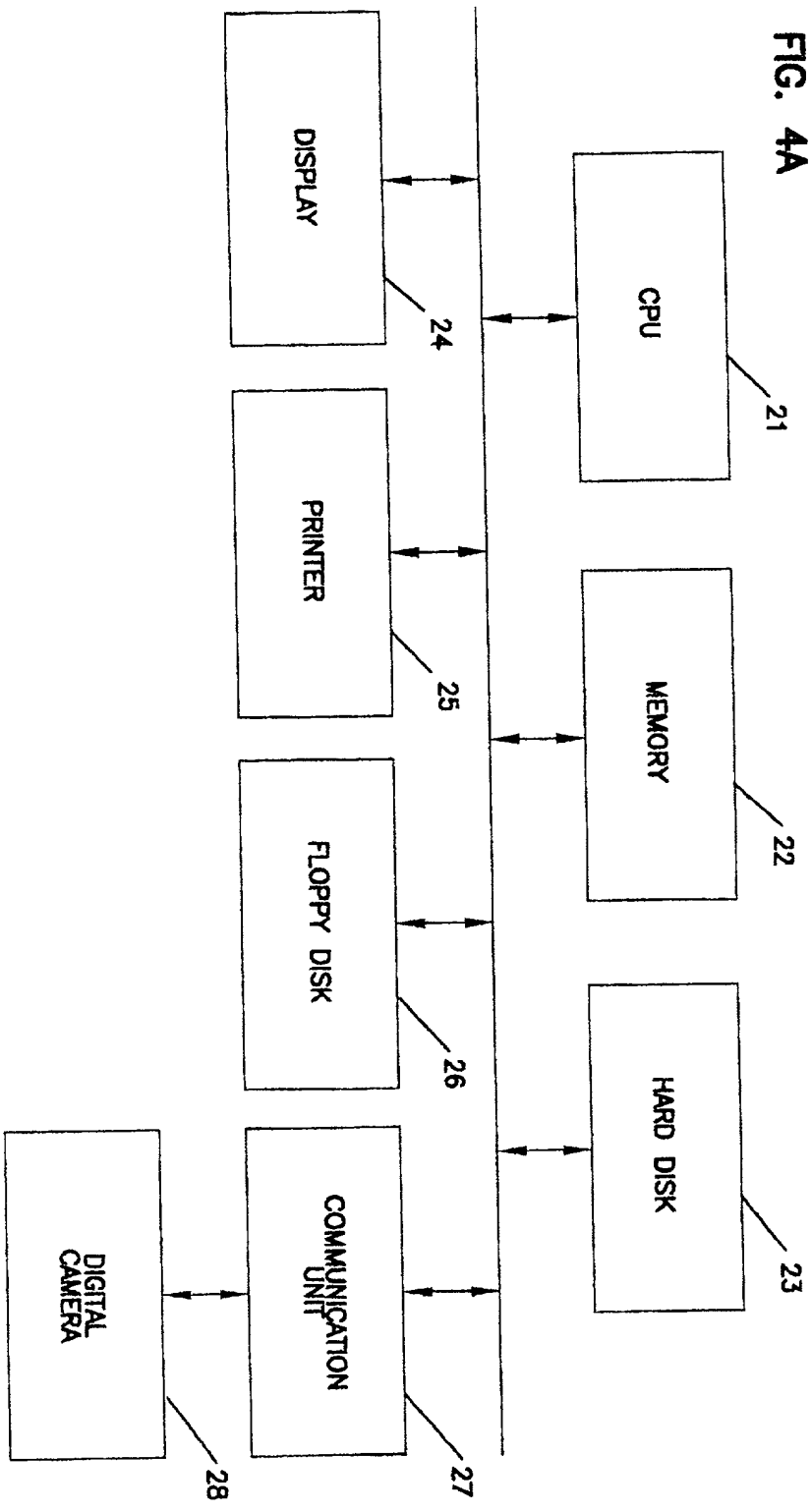

CPU
21
MEMORY
22
HARD DISK
23
DISPLAY
24
PRINTER
25
FLOPPY DISK
26
COMMUNICATION UNIT
27
DIGITAL CAMERA
28

FIG. 4B

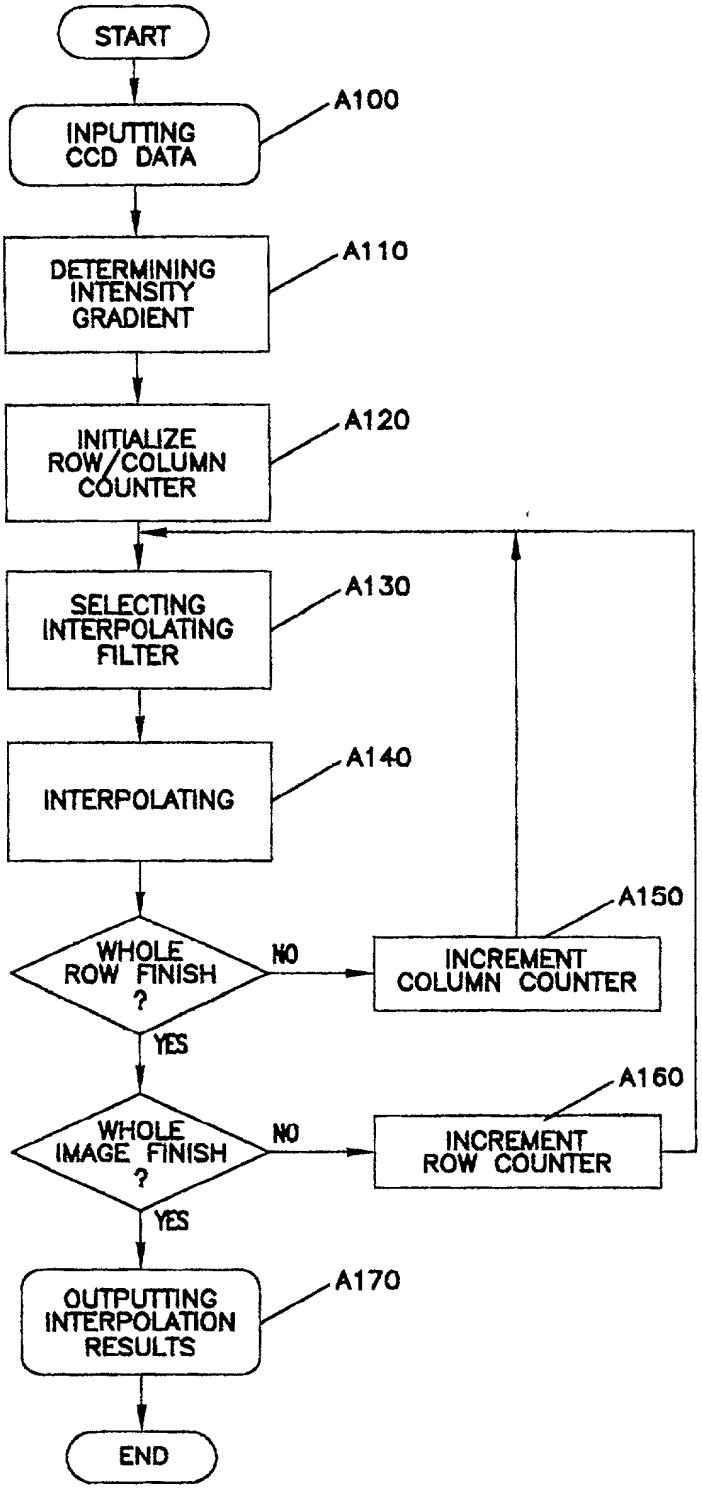

START
INPUTTING CCD DATA
A100
DETERMINING INTENSITY GRADIENT
A110
INITIALIZE ROW/COLUMN COUNTER
A120
SELECTING INTERPOLATING FILTER
A130
INTERPOLATING
A140
WHOLE ROW FINISH ?
NO
INCREMENT COLUMN COUNTER
A150
YES
WHOLE IMAGE FINISH ?
NO
INCREMENT ROW COUNTER
A160
YES
OUTPUTTING INTERPOLATION RESULTS
A170
END

FIG. 2
(PRIOR ART)

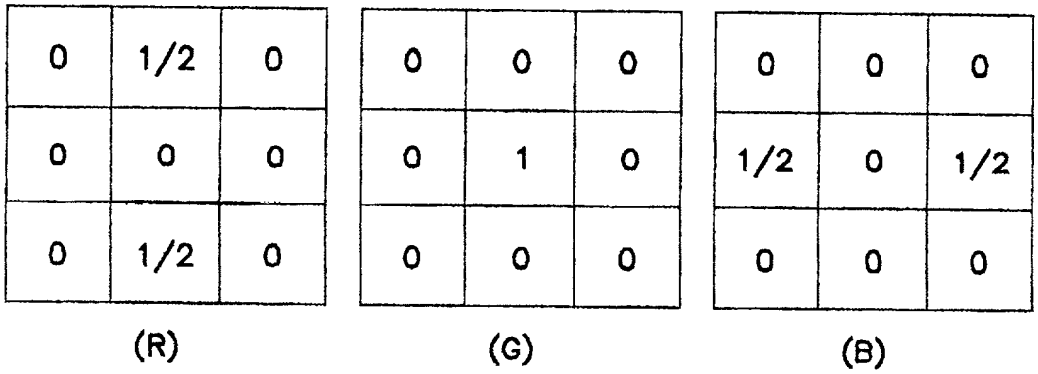


FIG. 7

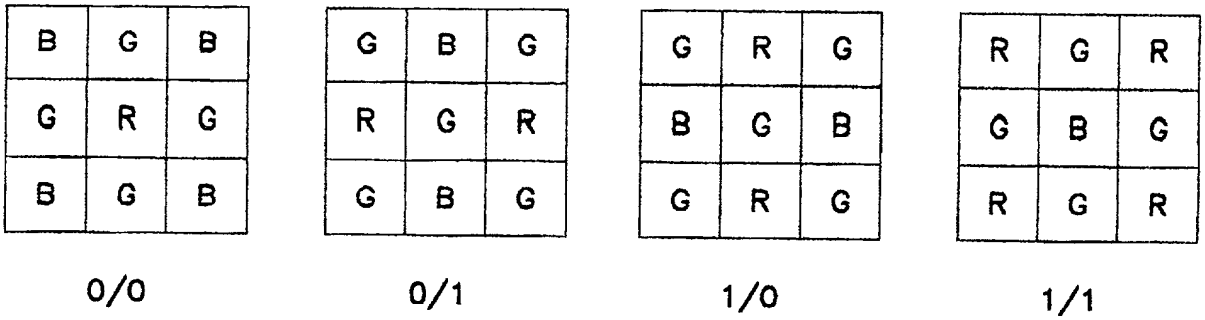


FIG. 8

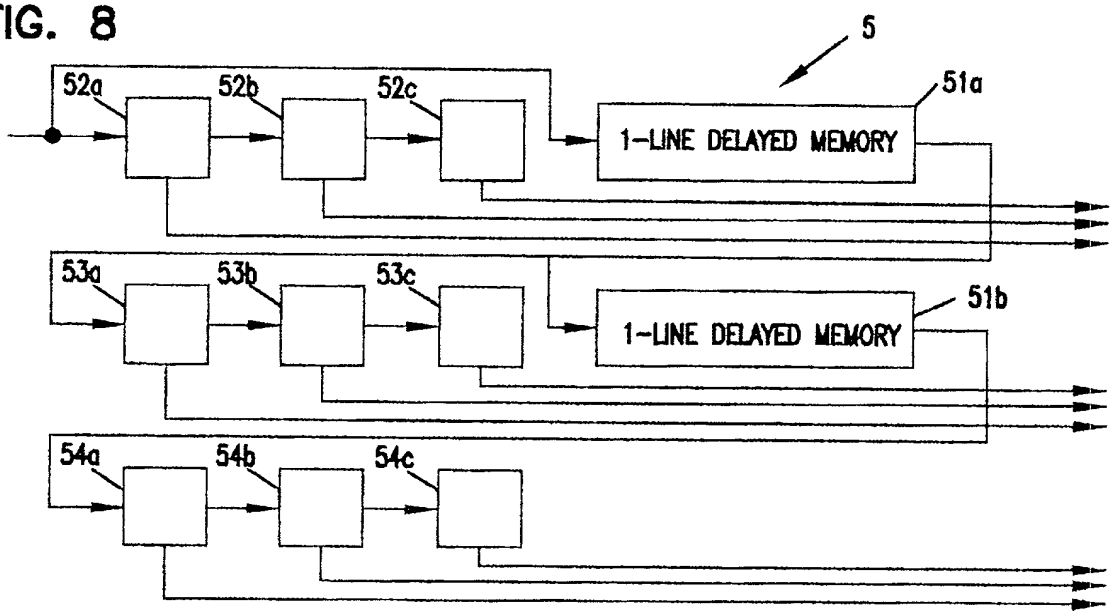


FIG. 11

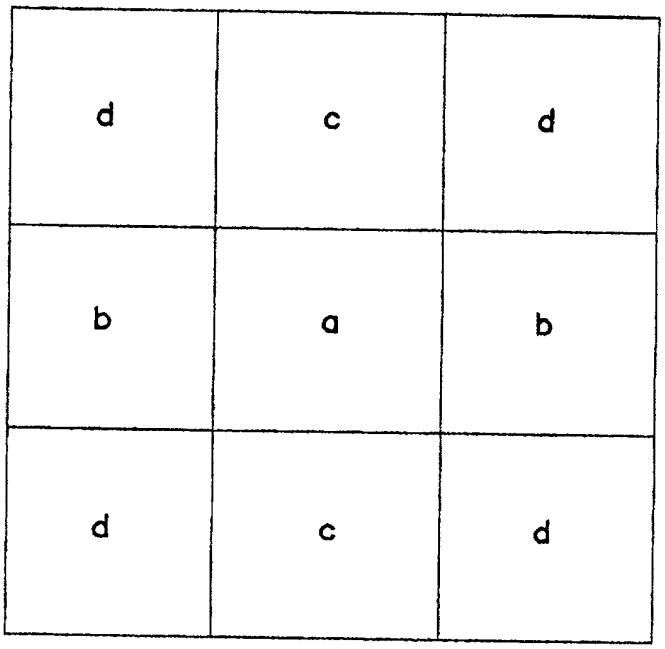


FIG. 12

VERTICALLY-SENSITIVE FILTER COEFFICIENTS

	R	G	B
0/0	0 -1/4 0 1/4 1 1/4 0 -1/4 0	0 1/4 0 1/4 0 1/4 0 1/4 0	1/4 1/4 1/4 -1/4 0 -1/4 1/4 1/4 1/4
0/1	-1/8 0 -1/8 1/2 1/2 1/2 -1/8 0 -1/8	1/8 0 1/8 0 1/2 0 1/8 0 1/8	1/8 1/2 1/8 0 -1/2 0 1/8 1/2 1/8
1/0	1/8 1/2 1/8 0 -1/2 0 1/8 1/2 1/8	1/8 0 1/8 0 1/2 0 1/8 0 1/8	-1/8 0 -1/8 1/2 1/2 1/2 -1/8 0 -1/8
1/1	1/4 1/4 1/4 -1/4 0 -1/4 1/4 1/4 1/4	0 1/4 0 1/4 0 1/4 0 1/4 0	0 -1/4 0 1/4 1 1/4 0 -1/4 0

FIG. 13

HORIZONTALLY-SENSITIVE FILTER COEFFICIENTS

	R	G	B
0/0	0 1/4 0 -1/4 1 -1/4 0 1/4 0	0 1/4 0 1/4 0 1/4 0 1/4 0	1/4 -1/4 1/4 1/4 0 1/4 1/4 -1/4 1/4
0/1	1/8 0 1/8 1/2 -1/2 1/2 1/8 0 1/8	1/8 0 1/8 0 1/2 0 1/8 0 1/8	-1/8 1/2 -1/8 0 1/2 0 -1/8 1/2 -1/8
1/0	-1/8 1/2 -1/8 0 1/2 0 -1/8 1/2 -1/8	1/8 0 1/8 0 1/2 0 1/8 0 1/8	1/8 0 1/8 1/2 -1/2 1/2 1/8 0 1/8
1/1	1/4 -1/4 1/4 1/4 0 1/4 1/4 -1/4 1/4	0 1/4 0 1/4 0 1/4 0 1/4 0	0 1/4 0 -1/4 1 -1/4 0 1/4 0

FIG. 14

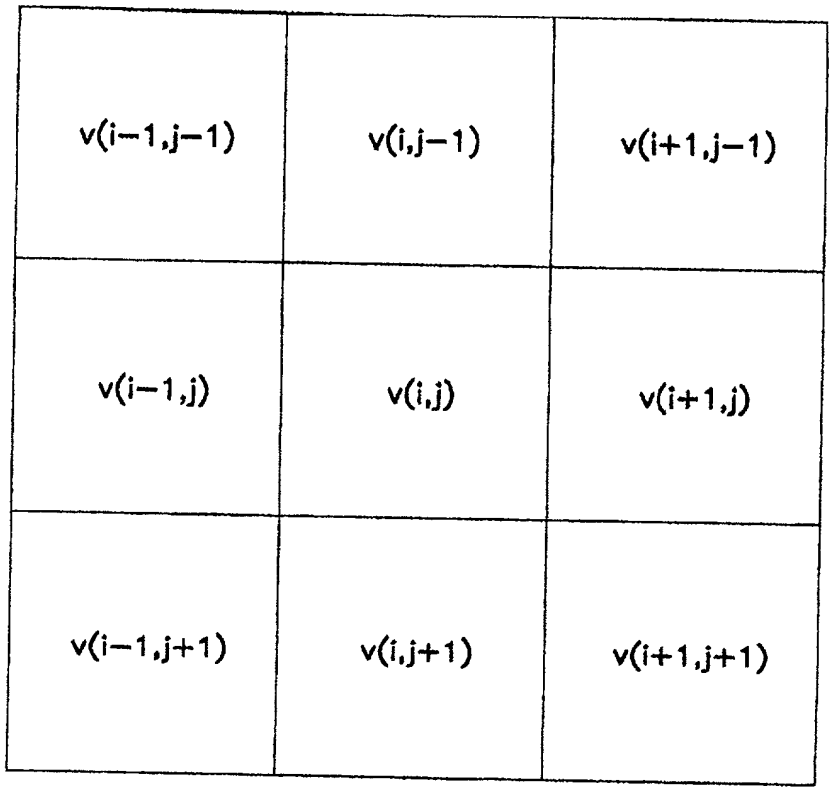
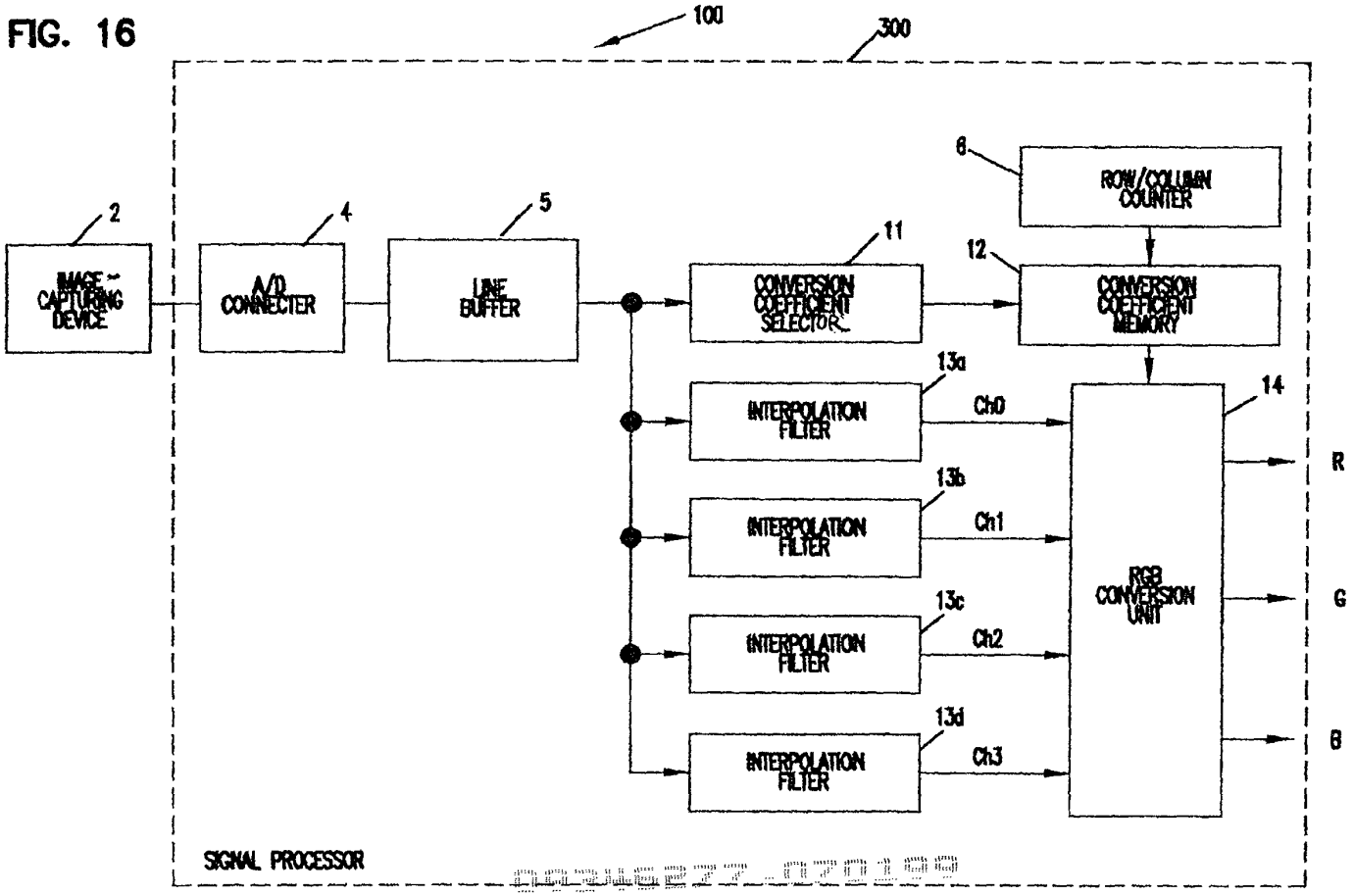


FIG. 15

255	255	255
0	255	0
255	255	255

FIG. 16



FROM :
FAX NO. : 8926275
Jun. 01 1999 11:30PM P10

FIG. 17

1	0	1
0	0	0
1	0	1

Ch0

0	1	0
0	0	0
0	1	0

Ch1

0	0	0
1	0	1
0	0	0

Ch2

0	0	0
0	1	0
0	0	0

Ch3

FIG. 19

POSITION : 0/0
$$\begin{bmatrix} 0 & 1/4 & -1/4 & 1 \\ 0 & 1/4 & 1/4 & 0 \\ 1/4 & -1/4 & 1/4 & 0 \end{bmatrix}$$

POSITION : 0/1
$$\begin{bmatrix} 1/8 & 0 & 1/2 & -1/2 \\ 1/8 & 0 & 0 & 1/2 \\ -1/8 & 1/2 & 0 & 1/2 \end{bmatrix}$$

POSITION : 1/0
$$\begin{bmatrix} -1/8 & 1/2 & 0 & 1/2 \\ 1/8 & 0 & 0 & 1/2 \\ 1/8 & 0 & 1/2 & -1/2 \end{bmatrix}$$

POSITION : 1/1
$$\begin{bmatrix} 1/4 & -1/4 & 1/4 & 0 \\ 0 & 1/4 & 1/4 & 0 \\ 0 & 1/4 & -1/4 & 1 \end{bmatrix}$$

HORIZONTAL GRADIENT MATRIX

POSITION : 0/0
$$\begin{bmatrix} 0 & -1/4 & 1/4 & 1 \\ 0 & 1/4 & 1/4 & 0 \\ 1/4 & 1/4 & -1/4 & 0 \end{bmatrix}$$

POSITION : 0/1
$$\begin{bmatrix} -1/8 & 0 & 1/2 & 1/2 \\ 1/8 & 0 & 0 & 1/2 \\ 1/8 & 1/2 & 0 & -1/2 \end{bmatrix}$$

POSITION : 1/0
$$\begin{bmatrix} 1/8 & 1/2 & 0 & -1/2 \\ 1/8 & 0 & 0 & 1/2 \\ -1/8 & 0 & 1/2 & 1/2 \end{bmatrix}$$

POSITION : 1/1
$$\begin{bmatrix} 1/4 & 1/4 & -1/4 & 0 \\ 0 & 1/4 & 1/4 & 0 \\ 0 & -1/4 & 1/4 & 1 \end{bmatrix}$$

VERTICAL GRADIENT MATRIX

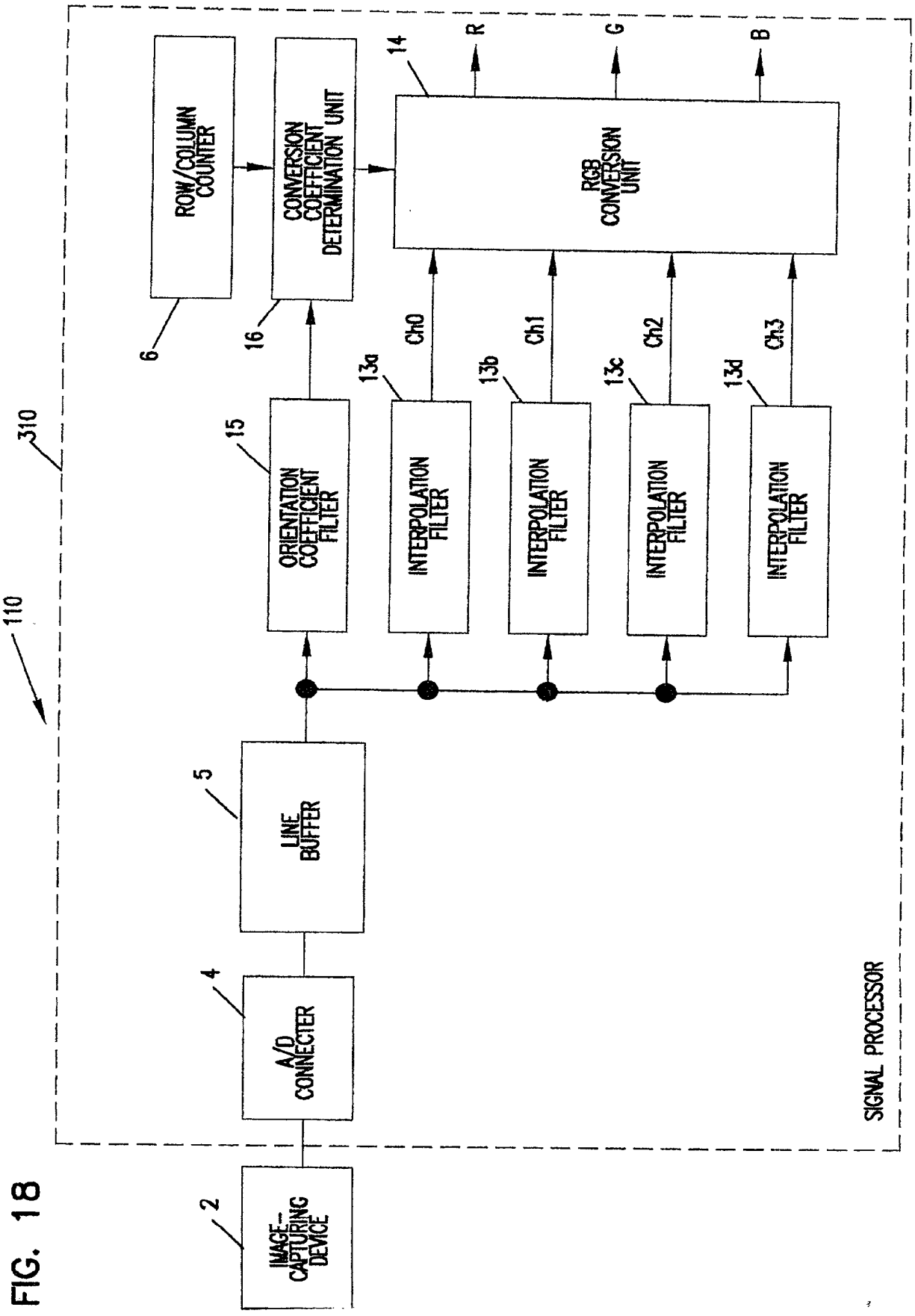


IMAGE-CAPTURING DEVICE
2
A/D CONNECTER
4
LINE BUFFER
5
ROW/COLUMN COUNTER
6
CONVERSION COEFFICIENT DETERMINATION UNIT
16
ORIENTATION COEFFICIENT FILTER
15
INTERPOLATION FILTER
13a
INTERPOLATION FILTER
13b
INTERPOLATION FILTER
13c
INTERPOLATION FILTER
13d
Ch0
Ch1
Ch2
Ch3
RGB CONVERSION UNIT
14
R
G
B
SIGNAL PROCESSOR
310
110

FIG. 18

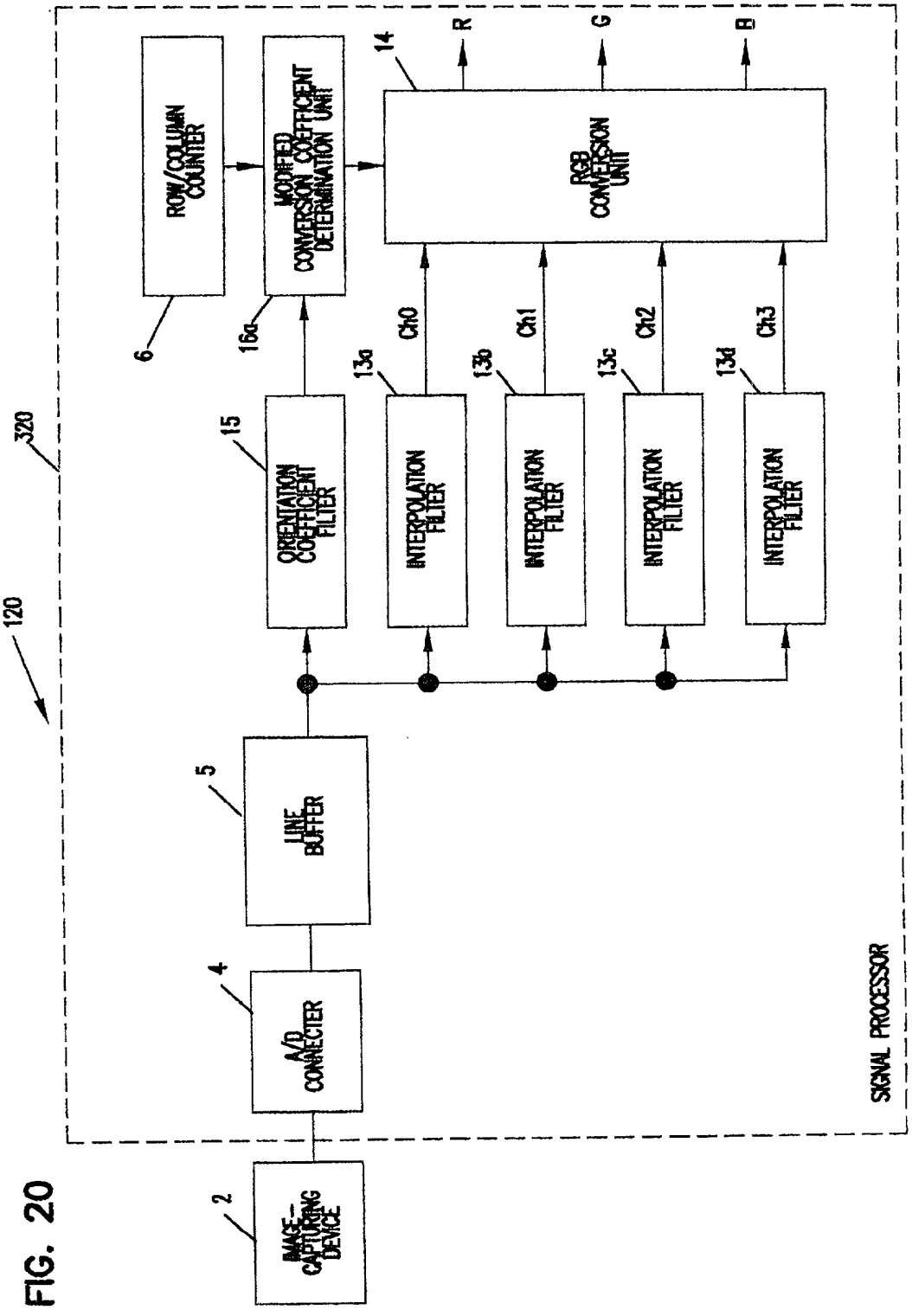

120
320
SIGNAL PROCESSOR
2
IMAGE-CAPTURING DEVICE
4
A/D CONVERTER
5
LINE BUFFER
15
ORIENTATION COEFFICIENT FILTER
13a
13b
13c
13d
INTERPOLATION FILTER
INTERPOLATION FILTER
INTERPOLATION FILTER
INTERPOLATION FILTER
Ch0
Ch1
Ch2
Ch3
6
ROW/COLUMN COUNTER
16a
MODIFIED CONVERSION COEFFICIENT DETERMINATION UNIT
14
RGB CONVERSION UNIT
R
G
B

FIG. 20

Docket No.
RCOH-1013

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

DIRECTION-SENSITIVE CORRECTION METHOD AND SYSTEM FOR DATA INCLUDING ABRUPT INTENSITY GRADIENTS

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
10-185851	Japan	7/1/98	☐
(Number)	(Country)	(Day/Month/Year Filed)	
			☐
(Number)	(Country)	(Day/Month/Year Filed)	
			☐
(Number)	(Country)	(Day/Month/Year Filed)	

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Ken I. Yoshida, Esq. **Reg. No. 37,009**
John L. Knoble, Esq. **Reg. No. 32,387**

Send Correspondence to: **Ken I. Yoshida, Esq.**
KNOBLE & YOSHIDA LLC
Eight Penn Center, Suite 1350
1628 John F. Kennedy Blvd., Philadelphia, PA 19103

Direct Telephone Calls to: *(name and telephone number)*
(215) 599-0600

Full name of sole or first inventor
Shin Aoki

Sole or first inventor's signature Date

Residence
Kanagawa, Japan

Citizenship
Japanese

Post Office Address
201 Daini Wakakusa Hausu, 4-15-1 Utsukushigaoka
Aoba-ku, Yokohama, Kanagawa, Japan

Full name of second inventor, if any

Second inventor's signature Date

Residence

Citizenship

Post Office Address